JC03 Rec'd PCT/PTC 25 JUL 2001

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U S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEY'S DOCKET NUMBER 1454.1068/RAG 09/889934
INTERNATIONAL APPLICATION NO. PCT/DE00/00278	INTERNATIONAL FILING DATE 1 February 2000	PRIORITY DATE CLAIMED 1 February 1999
TITLE OF INVENTION METHOD AND ARRANGEMENT FOR TRANSFORMING A PICTURE AREA		
APPLICANT(S) FOR DO/EO/US Andre KAUP		

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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [X] This is an express request to immediately begin national examination procedures (35 U.S.C. 371(f)).
3. [X] The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
4. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
5. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
6. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
7. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
8. [X] An oath or declaration of the inventor (35 U.S.C. 371(c)(4)).
9. [ ] A translation of the Annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 10-15 below concern document(s) or information included:

10. [X] An Information Disclosure Statement Under 37 CFR 1.97 and 1.98.
11. [X] An assignment document for recording.
    Please mail the recorded assignment document to:
    a. [X] the person whose signature, name & address appears at the bottom of this document.
    b. [ ] the following:
12. [X] A preliminary amendment.
13. [X] A substitute specification
14. [ ] A change of power of attorney and/or address letter.
15. [ ] Other items or information:

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[X] The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees as follows:

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS	11 -20=	0	x $ 0.00	0.00
	INDEPENDENT CLAIMS	2 -3=	0	x $ 80.00	0.00
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+$270.00	0.00
	BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4): [ ] Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO ....$1,000 [X] International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.. ....$ 860 [ ] International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO...................$ 710 [ ] International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provision of PCT Article 33(1)-(4)..............$ 690 [ ] International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) to (4) ....$ 100				860.00
	Surcharge of $130 for furnishing the National fee or oath or declaration later than [ ] 20 [ ] 30 mos. from the earliest claimed priority date (37 CFR 1.482(e)).				0.00
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			SUBTOTAL		860.00
	Processing fee of $130 for furnishing the English Translation later than [ ] 20 [ ] 30 mos. from the earliest claimed priority date (37 CFR 1.482(f)).				
			TOTAL NATIONAL FEE		0.00
	Fee for recording the enclosed assignment (37 CFR 1.21(h)).				+ 40.00
			TOTAL FEES ENCLOSED		900.00

a. [X] A check in the amount of $ 900.00 to cover the above fees is enclosed.
b. [ ] Please charge my Deposit Account No. 19-3935 in the Amount of $ to cover the above fees. A duplicate copy of this sheet is enclosed.
c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-3935. A duplicate copy of this sheet is enclosed.

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PATENT TRADEMARK OFFICE

7/25/01
DATE

Richard A. Gollhofer
Richard A. Gollhofer
REGISTRATION NO. 31,106

Docket No. 1454.1068/RAG

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Andre KAUP

Serial No. (Unassigned)   Group Art Unit: To be assigned

Confirmation No.

Filed: (concurrently)   Examiner: To be assigned

For: METHOD AND ARRANGEMENT FOR TRANSFORMING A PICTURE AREA

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Before examination of the above-identified application, please amend the application as follows:

IN THE SPECIFICATION

Please REPLACE the pending specification with the Substitute Specification attached hereto.

IN THE ABSTRACT

Please REPLACE the originally filed Abstract with the enclosed Substitute Abstract.

IN THE CLAIMS

Please CANCEL claims 1-14 without prejudice or disclaimer of any of the subject matter claimed therein and ADD new claims in accordance with the following:

15. A method for transforming a picture area, comprising:

carrying out a vertical transformation of the picture area and a horizontal transformation of the picture area in an order determined as follows

if the picture area is present in a line interlacing method, firstly the horizontal and then the vertical transformation is carried out, and

otherwise one of the horizontal and vertical transformation is selected to be carried out first for whichever a correlation of pixels of the picture area is stronger.

16. The method as claimed in claim 15, wherein an additional dimension is taken into account in the transformation.

17. The method as claimed in claim 16, wherein an additional transformation is carried out along a time dimension.

18. The method as claimed in claim 17, wherein a side information item containing the order of transformations is generated by the decision unit.

19. The method as claimed in claim 18, further comprising carrying out mirroring on a 45-degree before either transformation, so that the horizontal transformation follows from the vertical transformation.

20. The method as claimed in claim 18, further comprising carrying out mirroring on a 45-degree before either transformation, so that the vertical transformation follows from the horizontal transformation.

21. The method as claimed in claim 18, for use in a coder for compression of picture data.

22. The method as claimed in claim 21, wherein the side information item is used in a decoder for decompression of the picture area.

23. The method as claimed in claim 22, further comprising determining modes of operation of at least one of the coder and the decoder according to one of an MPEG standard and an H.26x standard.

24. The method as claimed in claim 17, wherein the transformation is one of a DCT transformation and an IDCT transformation which is an inverse thereof.

25. A system for transforming a picture area, comprising:

a transformation unit to perform vertical transformation and horizontal transformation of the picture area; and

a decision unit to control said transformation unit to first perform the horizontal transformation and then the vertical transformation if the picture area is present in a line interlacing method, and otherwise to first perform the one of the vertical and horizontal transformations for which a correlation of pixels of the picture area is stronger.

REMARKS

This Preliminary Amendment is submitted to improve the form of the English translation as filed. It is respectfully requested that this Preliminary Amendment be entered in the above-referenced application.

In accordance with the foregoing, claims 1-14 have been canceled and claims 15-25 have been added. Thus, claims 15-25 are pending and are under consideration.

A substitute specification is also being filed herewith. The substitute specification is accompanied by a marked-up copy of the original specification. No new matter has been added.

If there are any questions regarding these matters, such questions can be addressed by telephone to the undersigned. Otherwise, an early action on the merits is respectfully solicited.

If any further fees are required in connection with the filing of this Preliminary Amendment, please charge same to our Deposit Account No. 19-3935.

Respectfully submitted,

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Substitute Specification

TITLE OF THE INVENTION

[0001] METHOD AND ARRANGEMENT FOR TRANSFORMING A PICTURE AREA

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates to a method and an arrangement for transforming a picture area.

2. Description of the Related Art

[0003] Such a method with an associated arrangement is disclosed in J. De Lameillieure, R. Schäfer: "MPEG-2-Bildcodierung für das digitale Fernsehen" (MPEG-2 picture coding for digital television), Fernseh- und Kino-Technik, volume 48, No. 3/1994, pages 99-107. The known method serves in the MPEG standard as a coding method and is essentially based on the hybrid DCT (Discrete Cosine Transform) with motion compensation. A similar method is used for videophony at n x 64 kbit/s (CCITT Recommendation H.261), for TV contribution (CCR Recommendation 723) at 34 or 45 Mbit/s, and for multimedia applications at 1.2 Mbit/s (ISO-MPEG-1). Hybrid DCT comprises a temporal processing stage, which uses the relationships between successive pictures, and a spatial processing stage, which utilizes the correlation within a picture.

[0004] The spatial processing (intraframe coding) essentially corresponds to traditional DCT coding. The picture is broken down into blocks of 8 x 8 pixels which are each transformed into the frequency domain by DCT. The result is a matrix of 8 x 8 coefficients which approximately reflect the two-dimensional spatial frequencies in the transformed picture block. A coefficient with frequency 0 (DC component) represents and average gray-scale value of the picture block.

[0005] The transformation is followed by data expansion. However, in natural picture originals, a concentration of the energy around the DC component (DC value) will take place, while the very high-frequency coefficients are usually zero.

[0006] In a next step, spectral weighting of the coefficients is effected, with the result that the amplitude accuracy of the high-frequency coefficients is reduced. The properties of the human

eye, whereby high spatial frequencies are resolved less accurately than low spatial frequencies, are exploited in this case.

[0007] A second step of data reduction takes place in the form of an adaptive quantization through which the amplitude accuracy of the coefficients is reduced further or through which the small amplitudes are set to zero. In this case, the measure of the quantization depends on the occupancy of the output buffer: with the buffer empty, fine quantization is effected, with the result that more data are generated, while with the buffer full, coarser quantization is effected, as a result of which the volume of data is reduced.

[0008] After the quantization, the block is scanned diagonally ("zigzag" scanning), followed by entropy coding, which brings about the actual data reduction. Two effects are exploited for this purpose:

[0009] 1.) The statistics of the amplitude values (high amplitude values occur more rarely than low ones, so that the rare events are assigned long code words and the frequent events are assigned short code words (Variable Length Coding, VLC). This results, on average, in a lower data rate than in the case of coding with a fixed word length. The variable rate of the VLC is subsequently smoothed in the buffer memory.

[0010] 2.) Use is made of the fact that, starting from a specific value, in most cases only zeros will follow. Instead of all these zeros, only an EOB code (End Of Block) is transmitted, which leads to a significant coding gain in the compression of the picture data. Instead of the initial rate of 512 bits, in the example specified only 46 bits need be transmitted for this block, which corresponds to a compression factor of more than 11.

[0011] A further compression gain is obtained through the temporal processing (interframe coding). A lower data rate is required for coding differential pictures than for the original pictures, because the amplitude values are much lower.

[0012] However, the temporal differences are only small if the movements in the picture are also small. By contrast, if the movements in the picture are large, then large differences are produced, which are in turn difficult to code. For this reason, the picture-to-picture motion is measured (motion estimation) and compensated (motion compensation) before the difference

formation. In this case, the motion information is transmitted with the picture information, usually only one motion vector being used per macroblock (e.g. four 8 x 8 picture blocks).

[0013] Even smaller amplitude values of the differential pictures are obtained if motion-compensated bidirectional prediction is used instead of the prediction that is used.

[0014] In a motion-compensated hybrid coder, the picture signal itself is not transformed, but rather the temporal differential signal. For this reason, the coder is also provided with a temporal recursion loop, because the predictor must calculate the predicted value from the values of the already transmitted (coded) pictures. An identical temporal recursion loop is situated in the decoder, so that coder and decoder are fully synchronized.

[0015] In the MPEG-2 coding method, there are principally three different methods which can be used to process pictures:

[0016] I pictures: In the case of the I pictures, temporal prediction is not used, i.e. the picture values are directly transformed and coded, as illustrated in Figure 1. I pictures are used in order to be able to begin the decoding operation anew without knowledge of the temporal past, or in order to achieve resynchronization in the event of transmission errors.

[0017] P pictures: The P pictures are used to perform a temporal prediction; the DCT is applied to the temporal prediction error.

[0018] B pictures: In the case of the B pictures, the temporal bidirectional prediction error is calculated and then transformed. In principle, the bidirectional prediction works adaptively, i.e. forward prediction, backward prediction or interpolation are permitted.

[0019] In MPEG-2 coding, a picture sequence is divided into so-called GOPs (Group Of Pictures). n pictures between two I pictures form a GOP. The distance between the P pictures is designated by m, in each case m-1 B pictures being situated between the P pictures. However, the MPEG syntax leaves it to the user to choose m and n. m=1 means that no B pictures are used, and n=1 means that only I pictures are coded.

[0020] A column-by-column or row-by-row transformation is preferably effected in the context of the DCT transformation on the part of the encoder. In this case, the type of transformation is effected identically for all the picture data, which is disadvantageous for specific picture data.

SUMMARY OF THE INVENTION

[0021] The object of the invention consists in transforming a picture area, the order of vertical and horizontal transformation depending on predetermined conditions which are taken into account in a targeted manner. In this case, it is possible to achieve a significant improvement in the picture quality.

[0022] This object is achieved by a system for transforming a picture area, including a transformation unit to perform vertical transformation and horizontal transformation of the picture area; and a decision unit to control the transformation unit to first perform the horizontal transformation and then the vertical transformation if the picture area is present in a line interlacing method, and otherwise to first perform the one of the vertical and horizontal transformations for which a correlation of pixels of the picture area is stronger.

[0023] In order to achieve the object, a method for transforming a picture area is specified, in which firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation are carried out by a decision unit.

[0024] A development consists in the picture area having an irregular structure. In this case, it is particularly advantageous that the order of the transformations can be determined depending on a prescribed or a determined value in the decision unit or by the decision unit. Thus, depending on the picture area to be transformed and special features that are characteristic of the picture area, the order of horizontal and vertical transformation can be prescribed by the decision unit in such a way that the best possible result is obtained with regard to the compression of the picture area.

[0025] The order of the transformations is crucial in particular in the case of an irregular structure of the picture area, since, after each vertical or horizontal transformation, pixels of the irregular picture area are resorted and, as a result, a correlation of the pixels in the space domain can be lost. Such resorting may, in particular, be orientation along a horizontal or a vertical axis (line).

[0026] The decision unit determines the order of the transformations preferably using special features or a special feature of the picture area, its transmission type or a feature that is characteristic of it.

[0027] A refinement consists in the orientation of the picture area being effected along a horizontal line, or in the orientation being effected along a vertical line. In this case, pixels of the lines of the picture area are oriented on the vertical line, or pixels of the columns of the picture area are oriented on the horizontal line. In particular, each transformation (vertical or horizontal) is followed by a corresponding orientation. As a result of the orientation, i.e. the displacement of lines and/or columns of the picture area, a correlation in the space domain is lost under certain circumstances (in the case of an irregular structure for the picture area), since pixels originally lying next to one another will no longer necessarily lie next to one another after the orientation (e.g. correlation in the space domain). This information is used, in particular, to take the decision about the order of the transformations within the decision unit to the effect that the correlation of pixels lying next to one another in the space or time domain is optimally utilized.

[0028] A refinement furthermore consists in at least one of the following mechanisms being taken into account by the decision unit for determining the order of vertical and horizontal transformation:

[0029] a) In the event of transmission in the line interlacing method (interlaced) only every second line of a picture is represented (and transmitted). Alternation of the respective other second lines results, in a manner staggered over time, in pictures which represent moving pictures, the lines of in each case two temporally successive pictures complementing one another to form a frame. In the decision unit, e.g. the picture header is used to determine whether such transmission in the line interlacing method is present. If a line interlacing method is present, then the horizontal transformation is carried out first and then the vertical transformation. This exploits the fact that, in the line interlacing method, only every second line is transmitted and, consequently, the correlation of pixels is higher within a line than along a column.

[0030] b) Another mechanism consists, as described above, in that transformation being carried out first along whose direction the correlation of the picture area pixels to be transformed is greater.

[0031] Another development consists in an additional dimension being taken into account in the transformation, this additional dimension being examined with regard to the correlation of the pixels in the additional dimension. One example is that the additional dimension is a time axis (3D transformation).

[0032] A further refinement consists in a side information item containing the order of the transformations being generated by the decision unit. In this case, the side information item corresponds to a signal which is preferably transmitted to a receiver (decoder) and using which the receiver is able to infer the information about the order of the transformations. This order is to be taken into account correspondingly during the inverse operation of decoding.

[0033] In the context of another development, the vertical transformation follows from the horizontal transformation in that mirroring is carried out on a 45° axis before the transformation. A horizontal transformation follows from the vertical transformation in a corresponding manner. The mirroring (virtually) interchanges the transformation order.

[0034] The method is suitable for use in a coder for compression of picture data, e.g. an MPEG picture coder. A corresponding decoder is preferably augmented by a possibility of evaluating the side information signal in order to be able to carry out the correct order of vertical and horizontal transformation (or the operation that is respectively the inverse thereof) during the decoding of the picture area.

[0035] Coder and decoder preferably operate according to an MPEG standard or according to an H.26x standard.

[0036] A development consists in the transformation being a DCT transformation or an IDCT transformation that is the inverse thereof.

[0037] Furthermore, in order to achieve the object, an arrangement for transforming a picture area is specified, having a decision unit using which a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation of the picture area can be carried out.

[0038] This arrangement is particularly suitable for carrying out the method according to the invention or one of its developments explained above.

[0039] Exemplary embodiments of the invention are illustrated and explained below with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] In the figures:

[0041] Figure 1 shows a sketch illustrating steps of a transformation of a picture area;

[0042] Figure 2 shows a sketch illustrating a decision unit and the signals/values generated therefrom;

[0043] Figure 3 shows a sketch illustrating a transmitter and receiver for picture compression;

[0044] Figure 4 shows a sketch illustrating a picture coder and a picture decoder in greater detail; and

[0045] Figure 5 shows a possible instance of the decision unit in the form of a processor unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0046] Figure 1 illustrates steps of a transformation, in particular a DCT transformation for a predetermined picture area, which picture area has an irregular structure. A step 101 shows the irregular structure of the picture area in a line interlacing method, indicated by every second occupied line. In this case, the picture area is composed of the lines 105, 106, 107 and 108. In a step 102, the picture which is actually represented in the line interlacing method is shown, which again has the lines 105 to 108. The correlation of this picture area having an irregular structure is particularly high along the lines. Correspondingly, in the line interlacing method, firstly the lines are transformed after they have previously been oriented along a vertical line 109. The orientation results in a column-related displacement of adjacent pixels. The vertical transformation takes place in step 103. A horizontal orientation along a horizontal line 110 is carried out beforehand.

[0047] It would also be possible (additionally) to take account of a transformation along a time axis. Thus, step 101 can also be interpreted as a representation of a plurality of lines 105 to 108 or a plurality of picture areas 105 to 108 which are scanned along a time axis 111 at different instants in each case. The spatial information in the respective lines 105 to 108 or the respective picture areas 105 to 108 is high, whereas lower correlations between the individual

lines 105 to 108 or picture areas 105 to 108 are given as a result of the scanning along the time axis 111 in the direction of the time dimension.

[0048] Figure 2 illustrates a sketch illustrating a decision unit and the signals/values generated therefrom. An input signal or a plurality of input signals 200 are used by the decision unit 201 for determining which of a plurality of transformations (horizontal, vertical, temporal) are to be carried out in what order in order in each case to utilize the correlations in the space or time domain as well as possible, i.e. to take account of high correlations in such a way that an associated transformation is carried out first. The line interlacing method discussed in figure 1 serves as an example, which method is used by the decision unit 201 to carry out the horizontal transformation before the vertical transformation. The actual transformations are carried out in a unit 202, in which the picture areas are likewise oriented. The resulting coefficients 203 are the result of the transformation unit 202 (also cf. illustration in step 104). Furthermore, the decision unit 201 generates a side information item 203 comprising the order of the transformations to be carried out.

[0049] The arrangement illustrated in Fig. 2 is, in particular, part of a transmitter (coder) 301 as is shown in Fig. 3. Picture data 303, preferably in compressed form, are transmitted from the transmitter 301 to a receiver (decoder) 302. The side information item 203 described in figure 2 is likewise transmitted (identified here by a connection 304) from the transmitter 301 to the receiver 302, where the side information item 304 is decoded to yield the information about the order of the transformations.

[0050] Moreover, it shall be pointed out that, in principle, there are two possibilities for carrying out the transformations: either both transformations (horizontal and vertical) are actually interchanged. This leads to a not inconsiderable complexity in programming terms. As an alternative to this, it is possible to define the order of the transformations (using the decision unit 201), the vertical transformation following from the horizontal transformation in that the picture area is mirrored at a 45° axis (top left to bottom right). The mirroring (virtually) interchanges the transformation order. The mirroring operation on the part of the receiver 302 is to be taken into account in a corresponding manner.

[0051] Figure 4 shows a picture coder with an associated picture decoder in greater detail (block-based picture coding method in accordance with H.263 standard).

[0052] A video data stream to be coded, with temporally successive digitized pictures, is fed to a picture coding unit 201. The digitized pictures are subdivided into macroblocks 202, each macroblock having 16 x 16 pixels. The macroblock 202 comprises 4 picture blocks 203, 204, 205 and 206, each picture block containing 8 x 8 pixels which are assigned luminance values (brightness values). Furthermore, each macroblock 202 comprises two chrominance blocks 207 and 208 with chrominance values (color information, color saturation) assigned to the pixels.

[0053] The block of a picture contains a luminance value (= brightness), a first chrominance value (= hue) and a second chrominance value (= color saturation). In this case, luminance value, first chrominance value and second chrominance value are designated as color values.

[0054] The picture blocks are fed to a transform coding unit 209. In the case of differential picture coding, values to be coded of picture blocks of temporally preceding pictures are subtracted from the picture blocks that are currently to be coded; only the difference-formation information 210 is fed to the transform coding unit (Discrete Cosine Transform, DCT) 209. To that end, the current macroblock 202 is communicated to a motion estimation unit 229 via a connection 234. In the transform coding unit 209, spectral coefficients 211 are formed for the picture blocks or differential picture blocks to be coded and are fed to a quantization unit 212. This quantization unit 212 corresponds to the quantization apparatus according to the invention.

[0055] Quantized spectral coefficients 213 are fed both to a scan unit 214 and to an inverse quantization unit 215 in a backward path. After a scan method, e.g. a "zigzag" scan method, entropy coding is carried out on the scanned spectral coefficients 232 in an entropy coding unit 216 provided for this purpose. The entropy-coded spectral coefficients are transmitted as coded picture data 217 via a channel, preferably a line or a radio link, to a decoder.

[0056] In the inverse quantization unit 215, inverse quantization of the quantized spectral coefficients 213 takes place. Spectral coefficients 218 obtained in this way are fed to an inverse transform coding unit 219 (Inverse Discrete Cosine Transform, IDCT). Reconstructed coding values (also differential coding values) 220 are fed to an adder 221 in the differential picture mode. The adder 221 furthermore receives coding values of a picture block which are produced from a temporally preceding picture after a motion compensation that has already been carried out. Using the adder 221, reconstructed picture blocks 222 are formed and stored in a picture memory 223.

[0057] Chrominance values 224 of the reconstructed picture blocks 222 are fed from the picture memory 223 to a motion compensation unit 225. For brightness values 226, interpolation is effected in an interpolation unit 227 provided for this purpose. Using the interpolation, the number of brightness values contained in the respective picture block is preferably doubled. All the brightness values 228 are fed both to the motion compensation unit 225 and to the motion estimation unit 229. The motion estimation unit 229 additionally receives via the connection 234 the picture blocks of the macroblock (16 x 16 pixels) to be coded in each case. In the motion estimation unit 229, the motion estimation is effected taking account of the interpolated brightness values ("motion estimation on a half-pixel basis"). Preferably, the motion estimation comprises the determination of absolute differences of the individual brightness values in the macroblock 222 that is currently to be coded and the reconstructed macroblock from the temporally preceding picture.

[0058] The result of the motion estimation is a motion vector 230, which expresses a spatial displacement of the selected macroblock from the temporally preceding picture to the macroblock 202 to be coded.

[0059] Both brightness information and chrominance information related to the macroblock determined by the motion estimation unit 229 are displaced by the motion vector 230 and subtracted from the coding values of the macroblock 202 (see data path 231).

[0060] Figure 5 shows a processor unit PRZE suitable for carrying out transformation and/or compression/ decompression. The processor unit PRZE comprises a processor CPU, a memory SPE and an input/output interface IOS, which is utilized in various ways via an interface IFC: via a graphics interface, an output becomes visible on a monitor MON and/or is output on a printer PRT. An input is effected via a mouse MAS or a keyboard TAST. The processor unit PRZE also has a data bus BUS, which ensures the connection of a memory MEM, the processor CPU and the input/output interface IOS. Furthermore, additional components, e.g. additional memory, data storage device (hard disk) or scanner can be connected to the data bus BUS.

Substitute Abstract

METHOD AND ARRANGEMENT FOR TRANSFORMING A PICTURE AREA

ABSTRACT OF DISCLOSURE

A method for transforming a picture area is specified, in which firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation are carried out by a decision unit.

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Marked-up Substitute Specification

[Description]

TITLE OF THE INVENTION

[0001] METHOD AND ARRANGEMENT FOR TRANSFORMING A PICTURE AREA

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates to a method and an arrangement for transforming a picture area.

2. Description of the Related Art

[0003] Such a method with an associated arrangement is disclosed in [1] J. De Lameillieure, R. Schäfer: "MPEG-2-Bildcodierung für das digitale Fernsehen" (MPEG-2 picture coding for digital television), Fernseh- und Kino-Technik, volume 48, No. 3/1994, pages 99-107. The known method serves in the MPEG standard as a coding method and is essentially based on the hybrid DCT (Discrete Cosine Transform) with motion compensation. A similar method is used for videophony at n x 64 kbit/s (CCITT Recommendation H.261), for TV contribution (CCR Recommendation 723) at 34 or 45 Mbit/s, and for multimedia applications at 1.2 Mbit/s (ISO-MPEG-1). Hybrid DCT comprises a temporal processing stage, which uses the relationships between successive pictures, and a spatial processing stage, which utilizes the correlation within a picture.

[0004] The spatial processing (intraframe coding) essentially corresponds to traditional DCT coding. The picture is broken down into blocks of 8 x 8 pixels which are each transformed into the frequency domain by [means of] DCT. The result is a matrix of 8 x 8 coefficients which approximately reflect the two-dimensional spatial frequencies in the transformed picture block. A coefficient with frequency 0 (DC component) represents and average gray-scale value of the picture block.

[0005] The transformation is followed by data expansion. However, in natural picture originals, a concentration of the energy around the DC component (DC value) will take place, while the very high-frequency coefficients are usually zero.

[0006] In a next step, spectral weighting of the coefficients is effected, with the result that the amplitude accuracy of the high-frequency coefficients is reduced. The properties of the human eye, whereby high spatial frequencies are resolved less accurately than low spatial frequencies, are exploited in this case.

[0007] A second step of data reduction takes place in the form of an adaptive quantization through which the amplitude accuracy of the coefficients is reduced further or through which the small amplitudes are set to zero. In this case, the measure of the quantization depends on the occupancy of the output buffer: with the buffer empty, fine quantization is effected, with the result that more data are generated, while with the buffer full, coarser quantization is effected, as a result of which the volume of data is reduced.

[0008] After the quantization, the block is scanned diagonally ("zigzag" scanning), followed by entropy coding, which brings about the actual data reduction. Two effects are exploited for this purpose:

[0009] 1.) The statistics of the amplitude values (high amplitude values occur more rarely than low ones, so that the rare events are assigned long code words and the frequent events are assigned short code words (Variable Length Coding, VLC). This results, on average, in a lower data rate than in the case of coding with a fixed word length. The variable rate of the VLC is subsequently smoothed in the buffer memory.

[0010] 2.) Use is made of the fact that, starting from a specific value, in most cases only zeros will follow. Instead of all these zeros, only an EOB code (End Of Block) is transmitted, which leads to a significant coding gain in the compression of the picture data. Instead of the initial rate of 512 bits, in the example specified only 46 bits need be transmitted for this block, which corresponds to a compression factor of more than 11.

[0011] A further compression gain is obtained through the temporal processing (interframe coding). A lower data rate is required for coding differential pictures than for the original pictures, because the amplitude values are much lower.

[0012] However, the temporal differences are only small if the movements in the picture are also small. By contrast, if the movements in the picture are large, then large differences are

produced, which are in turn difficult to code. For this reason, the picture-to-picture motion is measured (motion estimation) and compensated (motion compensation) before the difference formation. In this case, the motion information is transmitted with the picture information, usually only one motion vector being used per macroblock (e.g. four 8 x 8 picture blocks).

[0013] Even smaller amplitude values of the differential pictures are obtained if motion-compensated bidirectional prediction is used instead of the prediction that is used.

[0014] In a motion-compensated hybrid coder, the picture signal itself is not transformed, but rather the temporal differential signal. For this reason, the coder is also provided with a temporal recursion loop, because the predictor must calculate the predicted value from the values of the already transmitted (coded) pictures. An identical temporal recursion loop is situated in the decoder, so that coder and decoder are fully synchronized.

[0015] In the MPEG-2 coding method, there are principally three different methods which can be used to process pictures:

[0016] I pictures: In the case of the I pictures, temporal prediction is not used, i.e. the picture values are directly transformed and coded, as illustrated in Figure 1. I pictures are used in order to be able to begin the decoding operation anew without knowledge of the temporal past, or in order to achieve resynchronization in the event of transmission errors.

[0017] P pictures: The P pictures are used to perform a temporal prediction; the DCT is applied to the temporal prediction error.

[0018] B pictures: In the case of the B pictures, the temporal bidirectional prediction error is calculated and then transformed. In principle, the bidirectional prediction works adaptively, i.e. forward prediction, backward prediction or interpolation are permitted.

[0019] In MPEG-2 coding, a picture sequence is divided into so-called GOPs (Group Of Pictures). n pictures between two I pictures form a GOP. The distance between the P pictures is designated by m, in each case m-1 B pictures being situated between the P pictures. However, the MPEG syntax leaves it to the user to choose m and n. m=1 means that no B pictures are used, and n=1 means that only I pictures are coded.

[0020] A column-by-column or row-by-row transformation is preferably effected in the context of the DCT transformation on the part of the encoder. In this case, the type of transformation is effected identically for all the picture data, which is disadvantageous for specific picture data.

SUMMARY OF THE INVENTION

[0021] The object of the invention consists in transforming a picture area, the order of vertical and horizontal transformation depending on predetermined conditions which are taken into account in a targeted manner. In this case, it is possible to achieve a significant improvement in the picture quality.

[0022] This object is achieved [in accordance with the features of the independent patent claims. Developments of the invention also emerge from the dependent claims.] by a system for transforming a picture area, including a transformation unit to perform vertical transformation and horizontal transformation of the picture area; and a decision unit to control the transformation unit to first perform the horizontal transformation and then the vertical transformation if the picture area is present in a line interlacing method, and otherwise to first perform the one of the vertical and horizontal transformations for which a correlation of pixels of the picture area is stronger.

[0023] In order to achieve the object, a method for transforming a picture area is specified, in which firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation are carried out by a decision unit.

[0024] A development consists in the picture area having an irregular structure. In this case, it is particularly advantageous that the order of the transformations can be determined depending on a prescribed or a determined value in the decision unit or by the decision unit. Thus, depending on the picture area to be transformed and special features that are characteristic of [said] the picture area, the order of horizontal and vertical transformation can be prescribed by the decision unit in such a way that the best possible result is obtained with regard to the compression of the picture area.

[0025] The order of the transformations is crucial in particular in the case of an irregular structure of the picture area, since, after each vertical or horizontal transformation, pixels of the irregular picture area are resorted and, as a result, a correlation of the pixels in the space

domain can be lost. Such resorting may, in particular, be orientation along a horizontal or a vertical axis (line).

[0026] The decision unit determines the order of the transformations preferably using special features or a special feature of the picture area, its transmission type or a feature that is characteristic of it.

[0027] A refinement consists in the orientation of the picture area being effected along a horizontal line, or in the orientation being effected along a vertical line. In this case, pixels of the lines of the picture area are oriented on the vertical line, or pixels of the columns of the picture area are oriented on the horizontal line. In particular, each transformation (vertical or horizontal) is followed by a corresponding orientation. As a result of the orientation, i.e. the displacement of lines and/or columns of the picture area, a correlation in the space domain is lost under certain circumstances (in the case of an irregular structure for the picture area), since pixels originally lying next to one another will no longer necessarily lie next to one another after the orientation (e.g. correlation in the space domain). This information is used, in particular, to take the decision about the order of the transformations within the decision unit to the effect that the correlation of pixels lying next to one another in the space or time domain is optimally utilized.

[0028] A refinement furthermore consists in at least one of the following mechanisms being taken into account by the decision unit for determining the order of vertical and horizontal transformation:

[0029] a) In the event of transmission in the line interlacing method (interlaced) only every second line of a picture is represented (and transmitted). Alternation of the respective other second lines results, in a manner staggered over time, in pictures which represent moving pictures, the lines of in each case two temporally successive pictures complementing one another to form a frame. In the decision unit, e.g. the picture header is used to determine whether such transmission in the line interlacing method is present. If a line interlacing method is present, then the horizontal transformation is carried out first and then the vertical transformation. This exploits the fact that, in the line interlacing method, only every second line is transmitted and, consequently, the correlation of pixels is higher within a line than along a column.

[0030] b) Another mechanism consists, as described above, in that transformation being carried out first along whose direction the correlation of the picture area pixels to be transformed is greater.

[0031] Another development consists in an additional dimension being taken into account in the transformation, this additional dimension being examined with regard to the correlation of the pixels in the additional dimension. One example is that the additional dimension is a time axis (3D transformation).

[0032] A further refinement consists in a side information item containing the order of the transformations being generated by the decision unit. In this case, the side information item corresponds to a signal which is preferably transmitted to a receiver (decoder) and using which [said] the receiver is able to infer the information about the order of the transformations. This order is to be taken into account correspondingly during the inverse operation of decoding.

[0033] In the context of another development, the vertical transformation follows from the horizontal transformation in that mirroring is carried out on a 45° axis before the transformation. A horizontal transformation follows from the vertical transformation in a corresponding manner. The mirroring (virtually) interchanges the transformation order.

[0034] The method is suitable for use in a coder for compression of picture data, e.g. an MPEG picture coder. A corresponding decoder is preferably augmented by a possibility of evaluating the side information signal in order to be able to carry out the correct order of vertical and horizontal transformation (or the operation that is respectively the inverse thereof) during the decoding of the picture area.

[0035] Coder and decoder preferably operate according to an MPEG standard or according to an H.26x standard.

[0036] A development consists in the transformation being a DCT transformation or an IDCT transformation that is the inverse thereof.

[0037] Furthermore, in order to achieve the object, an arrangement for transforming a picture area is specified, having a decision unit using which a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation of the picture area can be carried out.

[0038] This arrangement is particularly suitable for carrying out the method according to the invention or one of its developments explained above.

[0039] Exemplary embodiments of the invention are illustrated and explained below with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] In the figures:

[0041] Figure 1 shows a sketch illustrating steps of a transformation of a picture area;

[0042] Figure 2 shows a sketch illustrating a decision unit and the signals/values generated therefrom;

[0043] Figure 3 shows a sketch illustrating a transmitter and receiver for picture compression;

[0044] Figure 4 shows a sketch illustrating a picture coder and a picture decoder in greater detail; and

[0045] Figure 5 shows a possible instance of the decision unit in the form of a processor unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0046] Figure 1 illustrates steps of a transformation, in particular a DCT transformation for a predetermined picture area, which picture area has an irregular structure. A step 101 shows the irregular structure of the picture area in a line interlacing method, indicated by every second occupied line. In this case, the picture area is composed of the lines 105, 106, 107 and 108. In a step 102, the picture which is actually represented in the line interlacing method is shown, which again has the lines 105 to 108. The correlation of this picture area having an irregular structure is particularly high along the lines. Correspondingly, in the line interlacing method, firstly the lines are transformed after they have previously been oriented along a vertical line 109. The orientation results in a column-related displacement of adjacent pixels. The vertical transformation takes place in step 103. A horizontal orientation along a horizontal line 110 is carried out beforehand.

[0047] It would also be possible (additionally) to take account of a transformation along a time axis. Thus, step 101 can also be interpreted as a representation of a plurality of lines 105

to 108 or a plurality of picture areas 105 to 108 which are scanned along a time axis 111 at different instants in each case. The spatial information in the respective lines 105 to 108 or the respective picture areas 105 to 108 is high, whereas lower correlations between the individual lines 105 to 108 or picture areas 105 to 108 are given as a result of the scanning along the time axis 111 in the direction of the time dimension.

[0048] Figure 2 illustrates a sketch illustrating a decision unit and the signals/values generated therefrom. An input signal or a plurality of input signals 200 are used by the decision unit 201 for determining which of a plurality of transformations (horizontal, vertical, temporal) are to be carried out in what order in order in each case to utilize the correlations in the space or time domain as well as possible, i.e. to take account of high correlations in such a way that an associated transformation is carried out first. The line interlacing method discussed in figure 1 serves as an example, which method is used by the decision unit 201 to carry out the horizontal transformation before the vertical transformation. The actual transformations are carried out in a unit 202, in which the picture areas are likewise oriented. The resulting coefficients 203 are the result of the transformation unit 202 (also cf. illustration in step 104). Furthermore, the decision unit 201 generates a side information item 203 comprising the order of the transformations to be carried out.

[0049] The arrangement illustrated in Fig. 2 is, in particular, part of a transmitter (coder) 301 as is shown in Fig. 3. Picture data 303, preferably in compressed form, are transmitted from the transmitter 301 to a receiver (decoder) 302. The side information item 203 described in figure 2 is likewise transmitted (identified here by a connection 304) from the transmitter 301 to the receiver 302, where the side information item 304 is decoded to yield the information about the order of the transformations.

[0050] Moreover, it shall be pointed out that, in principle, there are two possibilities for carrying out the transformations: either both transformations (horizontal and vertical) are actually interchanged. This leads to a not inconsiderable complexity in programming terms. As an alternative to this, it is possible to define the order of the transformations (using the decision unit 201), the vertical transformation following from the horizontal transformation in that the picture area is mirrored at a 45° axis (top left to bottom right). The mirroring (virtually) interchanges the transformation order. The mirroring operation on the part of the receiver 302 is to be taken into account in a corresponding manner.

[0051] Figure 4 shows a picture coder with an associated picture decoder in greater detail (block-based picture coding method in accordance with H.263 standard).

[0052] A video data stream to be coded, with temporally successive digitized pictures, is fed to a picture coding unit 201. The digitized pictures are subdivided into macroblocks 202, each macroblock having 16 x 16 pixels. The macroblock 202 comprises 4 picture blocks 203, 204, 205 and 206, each picture block containing 8 x 8 pixels which are assigned luminance values (brightness values). Furthermore, each macroblock 202 comprises two chrominance blocks 207 and 208 with chrominance values (color information, color saturation) assigned to the pixels.

[0053] The block of a picture contains a luminance value (= brightness), a first chrominance value (= hue) and a second chrominance value (= color saturation). In this case, luminance value, first chrominance value and second chrominance value are designated as color values.

[0054] The picture blocks are fed to a transform coding unit 209. In the case of differential picture coding, values to be coded of picture blocks of temporally preceding pictures are subtracted from the picture blocks that are currently to be coded; only the difference-formation information 210 is fed to the transform coding unit (Discrete Cosine Transform, DCT) 209. To that end, the current macroblock 202 is communicated to a motion estimation unit 229 via a connection 234. In the transform coding unit 209, spectral coefficients 211 are formed for the picture blocks or differential picture blocks to be coded and are fed to a quantization unit 212. This quantization unit 212 corresponds to the quantization apparatus according to the invention.

[0055] Quantized spectral coefficients 213 are fed both to a scan unit 214 and to an inverse quantization unit 215 in a backward path. After a scan method, e.g. a "zigzag" scan method, entropy coding is carried out on the scanned spectral coefficients 232 in an entropy coding unit 216 provided for this purpose. The entropy-coded spectral coefficients are transmitted as coded picture data 217 via a channel, preferably a line or a radio link, to a decoder.

[0056] In the inverse quantization unit 215, inverse quantization of the quantized spectral coefficients 213 takes place. Spectral coefficients 218 obtained in this way are fed to an inverse transform coding unit 219 (Inverse Discrete Cosine Transform, IDCT). Reconstructed coding values (also differential coding values) 220 are fed to an adder 221 in the differential picture mode. The adder 221 furthermore receives coding values of a picture block which are produced from a temporally preceding picture after a motion compensation that has already been carried

out. Using the adder 221, reconstructed picture blocks 222 are formed and stored in a picture memory 223.

[0057] Chrominance values 224 of the reconstructed picture blocks 222 are fed from the picture memory 223 to a motion compensation unit 225. For brightness values 226, interpolation is effected in an interpolation unit 227 provided for this purpose. Using the interpolation, the number of brightness values contained in the respective picture block is preferably doubled. All the brightness values 228 are fed both to the motion compensation unit 225 and to the motion estimation unit 229. The motion estimation unit 229 additionally receives via the connection 234 the picture blocks of the macroblock (16 x 16 pixels) to be coded in each case. In the motion estimation unit 229, the motion estimation is effected taking account of the interpolated brightness values ("motion estimation on a half-pixel basis"). Preferably, the motion estimation comprises the determination of absolute differences of the individual brightness values in the macroblock 222 that is currently to be coded and the reconstructed macroblock from the temporally preceding picture.

[0058] The result of the motion estimation is a motion vector 230, which expresses a spatial displacement of the selected macroblock from the temporally preceding picture to the macroblock 202 to be coded.

[0059] Both brightness information and chrominance information related to the macroblock determined by the motion estimation unit 229 are displaced by the motion vector 230 and subtracted from the coding values of the macroblock 202 (see data path 231).

[0060] Figure 5 shows a processor unit PRZE suitable for carrying out transformation and/or compression/ decompression. The processor unit PRZE comprises a processor CPU, a memory SPE and an input/output interface IOS, which is utilized in various ways via an interface IFC: via a graphics interface, an output becomes visible on a monitor MON and/or is output on a printer PRT. An input is effected via a mouse MAS or a keyboard TAST. The processor unit PRZE also has a data bus BUS, which ensures the connection of a memory MEM, the processor CPU and the input/output interface IOS. Furthermore, additional components, e.g. additional memory, data storage device (hard disk) or scanner can be connected to the data bus BUS.

[0061] [Bibliography:] [1] [J. De Lameillieure, R. Schäfer: "MPEG-2-Bildcodierung für das digitale Fernsehen"] [MPEG-2 picture coding for digital television] [, Fernseh- und Kino-Technik, volume 48, No. 3/1994, pages 99-107.]

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Description

Method and arrangement for transforming a picture area

The invention relates to a method and an arrangement for transforming a picture area.

Such a method with an associated arrangement is disclosed in [1]. The known method serves in the MPEG standard as a coding method and is essentially based on the hybrid DCT (Discrete Cosine Transform) with motion compensation. A similar method is used for videophony at n × 64 kbit/s (CCITT Recommendation H.261), for TV contribution (CCR Recommendation 723) at 34 or 45 Mbit/s, and for multimedia applications at 1.2 Mbit/s (ISO-MPEG-1). Hybrid DCT comprises a temporal processing stage, which uses the relationships between successive pictures, and a spatial processing stage, which utilizes the correlation within a picture.

The spatial processing (intraframe coding) essentially corresponds to traditional DCT coding. The picture is broken down into blocks of 8×8 pixels which are each transformed into the frequency domain by means of DCT. The result is a matrix of 8×8 coefficients which approximately reflect the two-dimensional spatial frequencies in the transformed picture block. A coefficient with frequency 0 (DC component) represents and average gray-scale value of the picture block.

The transformation is followed by data expansion. However, in natural picture originals, a concentration of the energy around the DC component (DC value) will take place, while the very high-frequency coefficients are usually zero.

In a next step, spectral weighting of the coefficients is effected, with the result that the amplitude accuracy of the high-frequency coefficients is reduced. The properties of the human eye, whereby high spatial frequencies are resolved less accurately than low spatial frequencies, are exploited in this case.

A second step of data reduction takes place in the form of an adaptive quantization through which the amplitude accuracy of the coefficients is reduced further or through which the small amplitudes are set to zero. In this case, the measure of the quantization depends on the occupancy of the output buffer: with the buffer empty, fine quantization is effected, with the result that more data are generated, while with the buffer full, coarser quantization is effected, as a result of which the volume of data is reduced.

After the quantization, the block is scanned diagonally ("zigzag" scanning), followed by entropy coding, which brings about the actual data reduction. Two effects are exploited for this purpose:

1.) The statistics of the amplitude values (high amplitude values occur more rarely than low ones, so that the rare events are assigned long code words and the frequent events are assigned short code words (Variable Length Coding, VLC). This results, on average, in a lower data rate than in the case of coding with a fixed word length. The variable rate of the VLC is subsequently smoothed in the buffer memory.

2.) Use is made of the fact that, starting from a specific value, in most cases only zeros will follow. Instead of all these zeros, only an EOB code (End Of Block) is transmitted, which leads to

a significant coding gain in the compression of the picture data. Instead of the initial rate of 512 bits, in the example specified only 46 bits need be transmitted for this

block, which corresponds to a compression factor of more than 11.

A further compression gain is obtained through the temporal processing (interframe coding). A lower data rate is required for coding differential pictures than for the original pictures, because the amplitude values are much lower.

However, the temporal differences are only small if the movements in the picture are also small. By contrast, if the movements in the picture are large, then large differences are produced, which are in turn difficult to code. For this reason, the picture-to-picture motion is measured (motion estimation) and compensated (motion compensation) before the difference formation. In this case, the motion information is transmitted with the picture information, usually only one motion vector being used per macroblock (e.g. four 8×8 picture blocks).

Even smaller amplitude values of the differential pictures are obtained if motion-compensated bidirectional prediction is used instead of the prediction that is used.

In a motion-compensated hybrid coder, the picture signal itself is not transformed, but rather the temporal differential signal. For this reason, the coder is also provided with a temporal recursion loop, because the predictor must calculate the predicted value from the values of the already transmitted (coded) pictures. An identical temporal recursion loop is situated in the decoder, so that coder and decoder are fully synchronized.

In the MPEG-2 coding method, there are principally three different methods which can be used to process pictures:

I pictures: In the case of the I pictures, temporal prediction is not used, i.e. the picture values are directly transformed and coded, as illustrated in Figure 1. I pictures are used in order to be able to begin the decoding operation anew without knowledge of the temporal past, or in order to achieve resynchronization in the event of transmission errors.

P pictures: The P pictures are used to perform a temporal prediction; the DCT is applied to the temporal prediction error.

B pictures: In the case of the B pictures, the temporal bidirectional prediction error is calculated and then transformed. In principle, the bidirectional prediction works adaptively, i.e. forward prediction, backward prediction or interpolation are permitted.

In MPEG-2 coding, a picture sequence is divided into so-called GOPs (<u>G</u>roup <u>O</u>f <u>P</u>ictures). n pictures between two I pictures form a GOP. The distance between the P pictures is designated by m, in each case m-1 B pictures being situated between the P pictures. However, the MPEG syntax leaves it to the user to choose m and n. m=1 means that no B pictures are used, and n=1 means that only I pictures are coded.

A column-by-column or row-by-row transformation is preferably effected in the context of the DCT transformation on the part of the encoder. In this case, the type of transformation is effected identically for all the picture data, which is disadvantageous for specific picture data.

The **object** of the invention consists in transforming a picture area, the order of vertical and

horizontal transformation depending on predetermined conditions which are taken into account in a targeted manner.

In this case, it is possible to achieve a significant improvement in the picture quality.

This object is achieved in accordance with the features of the independent patent claims. Developments of the invention also emerge from the dependent claims.

In order to achieve the object, a method for transforming a picture area is specified, in which firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation are carried out by a decision unit.

A development consists in the picture area having an irregular structure.

In this case, it is particularly advantageous that the order of the transformations can be determined depending on a prescribed or a determined value in the decision unit or by the decision unit. Thus, depending on the picture area to be transformed and special features that are characteristic of said picture area, the order of horizontal and vertical transformation can be prescribed by the decision unit in such a way that the best possible result is obtained with regard to the compression of the picture area.

The order of the transformations is crucial in particular in the case of an irregular structure of the picture area, since, after each vertical or horizontal transformation, pixels of the irregular picture area are resorted and, as a result, a

correlation of the pixels in the space domain can be lost. Such resorting may, in particular, be orientation along a horizontal or a vertical axis (line).

The decision unit determines the order of the transformations preferably using special features or a special feature of the picture area, its transmission type or a feature that is characteristic of it.

A refinement consists in the orientation of the picture area being effected along a horizontal line, or in the orientation being effected along a vertical line. In this case, pixels of the lines of the picture area are oriented on the vertical line, or pixels of the columns of the picture area are oriented on the horizontal line. In particular, each transformation (vertical or horizontal) is followed by a corresponding orientation. As a result of the orientation, i.e. the displacement of lines and/or columns of the picture area, a correlation in the space domain is lost under certain circumstances (in the case of an irregular structure for the picture area), since pixels originally lying next to one another will no longer necessarily lie next to one another after the orientation (e.g. correlation in the space domain). This information is used, in particular, to take the decision about the order of the transformations within the decision unit to the effect that the correlation of pixels lying next to one another in the space or time domain is optimally utilized.

A refinement furthermore consists in at least one of the following mechanisms being taken into account by the decision unit for determining the order of vertical and horizontal transformation:

a) In the event of transmission in the line interlacing method (interlaced) only every second line of a picture is represented (and transmitted). Alternation of the respective other second lines results, in a manner staggered over time, in pictures which represent moving pictures, the lines of in each case two temporally successive pictures complementing one another to form a frame. In the decision unit, e.g. the picture header is used to determine whether such transmission in the line interlacing method is present. If a line interlacing method is present, then the horizontal transformation is carried out first and then the vertical transformation. This exploits the fact that, in the line interlacing method, only every second line is transmitted and, consequently, the correlation of pixels is higher within a line than along a column.

b) Another mechanism consists, as described above, in that transformation being carried out first along whose direction the correlation of the picture area pixels to be transformed is greater.

Another development consists in an additional dimension being taken into account in the transformation, this additional dimension being examined with regard to the correlation of the pixels in the additional dimension. One example is that the additional dimension is a time axis (3D transformation).

A further refinement consists in a side information item containing the order of the transformations being generated by the decision unit. In this case, the side information item corresponds to a signal which is preferably transmitted to a receiver (decoder) and using which said receiver is able to infer the

information about the order of the transformations. This order is to be taken into account correspondingly during the inverse operation of decoding.

In the context of another development, the vertical transformation follows from the horizontal transformation in that mirroring is carried out on a 45° axis before the transformation. A horizontal transformation follows from the vertical transformation in a corresponding manner. The mirroring (virtually) interchanges the transformation order.

The method is suitable for use in a coder for compression of picture data, e.g. an MPEG picture coder. A corresponding decoder is preferably augmented by a possibility of evaluating the side information signal in order to be able to carry out the correct order of vertical and horizontal transformation (or the operation that is respectively the inverse thereof) during the decoding of the picture area.

Coder and decoder preferably operate according to an MPEG standard or according to an H.26x standard.

A development consists in the transformation being a DCT transformation or an IDCT transformation that is the inverse thereof.

Furthermore, in order to achieve the object, an arrangement for transforming a picture area is specified, having a decision unit using which a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation of the picture area can be carried out.

This arrangement is particularly suitable for carrying out the method according to the invention or one of its developments explained above.

Exemplary embodiments of the invention are illustrated and explained below with reference to the drawings.

In the figures:

Figure 1 shows a sketch illustrating steps of a transformation of a picture area;

Figure 2 shows a sketch illustrating a decision unit and the signals/values generated therefrom;

Figure 3 shows a sketch illustrating a transmitter and receiver for picture compression;

Figure 4 shows a sketch illustrating a picture coder and a picture decoder in greater detail;

Figure 5 shows a possible instance of the decision unit in the form of a processor unit.

Figure 1 illustrates steps of a transformation, in particular a DCT transformation for a predetermined picture area, which picture area has an irregular structure. A step 101 shows the irregular structure of the picture area in a line interlacing method, indicated by every second occupied line. In this case, the picture area is composed of the lines 105, 106, 107 and 108. In a step 102, the picture which is actually represented in the line interlacing method is shown, which again has the lines 105 to 108. The correlation of this picture area having an irregular structure is particularly high along the lines. Correspondingly, in the line interlacing method, firstly the lines are transformed after they have previously been oriented along a vertical line 109. The orientation results in a column-related displacement of adjacent pixels. The vertical transformation takes place in

step 103. A horizontal orientation along a horizontal line 110 is carried out beforehand.

It would also be possible (additionally) to take account of a transformation along a time axis. Thus, step 101 can also be interpreted as a representation of a plurality of lines 105 to 108 or a plurality of picture areas 105 to 108 which are scanned along a time axis 111 at different instants in each case. The spatial information in the respective lines 105 to 108 or the respective picture areas 105 to 108 is high, whereas lower correlations between the individual lines 105 to 108 or picture areas 105 to 108 are given as a result of the scanning along the time axis 111 in the direction of the time dimension.

Figure 2 illustrates a sketch illustrating a decision unit and the signals/values generated therefrom. An input signal or a plurality of input signals 200 are used by the decision unit 201 for determining which of a plurality of transformations (horizontal, vertical, temporal) are to be carried out in what order in order in each case to utilize the correlations in the space or time domain as well as possible, i.e. to take account of high correlations in such a way that an associated transformation is carried out first. The line interlacing method discussed in figure 1 serves as an example, which method is used by the decision unit 201 to carry out the horizontal transformation before the vertical transformation. The actual transformations are carried out in a unit 202, in which the picture areas are likewise oriented. The resulting coefficients 203 are the result of the transformation unit 202 (also cf. illustration in step 104). Furthermore, the decision unit 201 generates a side information item 203 comprising the order of the transformations to be carried out.

The arrangement illustrated in figure 2 is, in particular, part of a transmitter (coder) 301 as is shown in **figure 3**. Picture data 303, preferably in compressed form, are transmitted from the transmitter 301 to a receiver (decoder) 302. The side information item 203 described in figure 2 is likewise transmitted (identified here by a connection 304) from the transmitter 301 to the receiver 302, where the side information item 304 is decoded to yield the information about the order of the transformations.

Moreover, it shall be pointed out that, in principle, there are two possibilities for carrying out the transformations: either both transformations (horizontal and vertical) are actually interchanged. This leads to a not inconsiderable complexity in programming terms. As an alternative to this, it is possible to define the order of the transformations (using the decision unit 201), the vertical transformation following from the horizontal transformation in that the picture area is mirrored at a 45° axis (top left to bottom right). The mirroring (virtually) interchanges the transformation order. The mirroring operation on the part of the receiver 302 is to be taken into account in a corresponding manner.

Figure 4 shows a picture coder with an associated picture decoder in greater detail (block-based picture coding method in accordance with H.263 standard).

A video data stream to be coded, with temporally successive digitized pictures, is fed to a picture coding unit 201. The digitized pictures are subdivided into macroblocks 202, each macroblock having 16×16 pixels. The macroblock 202 comprises 4 picture blocks 203, 204, 205 and 206, each picture block containing

8×8 pixels which are assigned luminance values (brightness values). Furthermore, each macroblock 202 comprises two chrominance blocks 207 and 208 with chrominance values (color information, color saturation) assigned to the pixels.

The block of a picture contains a luminance value (= brightness), a first chrominance value (= hue) and a second chrominance value (= color saturation). In this case, luminance value, first chrominance value and second chrominance value are designated as color values.

The picture blocks are fed to a transform coding unit 209. In the case of differential picture coding, values to be coded of picture blocks of temporally preceding pictures are subtracted from the picture blocks that are currently to be coded; only the difference-formation information 210 is fed to the transform coding unit (Discrete Cosine Transform, DCT) 209. To that end, the current macroblock 202 is communicated to a motion estimation unit 229 via a connection 234. In the transform coding unit 209, spectral coefficients 211 are formed for the picture blocks or differential picture blocks to be coded and are fed to a quantization unit 212. This quantization unit 212 corresponds to the quantization apparatus according to the invention.

Quantized spectral coefficients 213 are fed both to a scan unit 214 and to an inverse quantization unit 215 in a backward path. After a scan method, e.g. a "zigzag" scan method, entropy coding is carried out on the scanned spectral coefficients 232 in an entropy coding unit 216 provided for this purpose. The entropy-coded spectral coefficients are transmitted as coded picture data 217 via a channel, preferably a line or a radio link, to a decoder.

In the inverse quantization unit 215, inverse quantization of the quantized spectral coefficients 213 takes place. Spectral coefficients 218 obtained in this way are fed to an inverse transform coding unit 219 (Inverse Discrete Cosine Transform, IDCT). Reconstructed coding values (also differential coding values) 220 are fed to an adder 221 in the differential picture mode. The adder 221 furthermore receives coding values of a picture block which are produced from a temporally preceding picture after a motion compensation that has already been carried out. Using the adder 221, reconstructed picture blocks 222 are formed and stored in a picture memory 223.

Chrominance values 224 of the reconstructed picture blocks 222 are fed from the picture memory 223 to a motion compensation unit 225. For brightness values 226, interpolation is effected in an interpolation unit 227 provided for this purpose. Using the interpolation, the number of brightness values contained in the respective picture block is preferably doubled. All the brightness values 228 are fed both to the motion compensation unit 225 and to the motion estimation unit 229. The motion estimation unit 229 additionally receives via the connection 234 the picture blocks of the macroblock (16×16 pixels) to be coded in each case. In the motion estimation unit 229, the motion estimation is effected taking account of the interpolated brightness values ("motion estimation on a half-pixel basis"). Preferably, the motion estimation comprises the determination of absolute differences of the individual brightness values in the macroblock 222 that is currently to be coded and the reconstructed macroblock from the temporally preceding picture.

The result of the motion estimation is a motion vector 230, which expresses a spatial displacement of the

selected macroblock from the temporally preceding picture to the macroblock 202 to be coded.

Both brightness information and chrominance information related to the macroblock determined by the motion estimation unit 229 are displaced by the motion vector 230 and subtracted from the coding values of the macroblock 202 (see data path 231).

Figure 5 shows a processor unit PRZE suitable for carrying out transformation and/or compression/ decompression. The processor unit PRZE comprises a processor CPU, a memory SPE and an input/output interface IOS, which is utilized in various ways via an interface IFC: via a graphics interface, an output becomes visible on a monitor MON and/or is output on a printer PRT. An input is effected via a mouse MAS or a keyboard TAST. The processor unit PRZE also has a data bus BUS, which ensures the connection of a memory MEM, the processor CPU and the input/output interface IOS. Furthermore, additional components, e.g. additional memory, data storage device (hard disk) or scanner can be connected to the data bus BUS.

Bibliography:

[1] J. De Lameillieure, R. Schäfer: "MPEG-2-Bildcodierung für das digitale Fernsehen" [MPEG-2 picture coding for digital television], Fernseh- und Kino-Technik, volume 48, No. 3/1994, pages 99-107.

<u>Patent Claims</u>

1. A method for transforming a picture area, in which, depending on a decision unit, firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation are carried out.

2. The method as claimed in claim 1, in which the picture area has an irregular structure.

3. The method as claimed in claim 1 or 2,
   a) in which, before or after the vertical transformation, the picture area is oriented along a horizontal line;
   b) in which, before or after the horizontal transformation, the picture area is oriented along a vertical line.

4. The method as claimed in one of claims 1 to 3, in which at least one of the following mechanisms is carried out by the decision unit:
   a) if the picture area is present in the line interlacing method, firstly the horizontal and then the vertical transformation is carried out;
   b) that (horizontal or vertical) transformation is carried out first along which a correlation of pixels of the picture area is stronger.

5. The method as claimed in one of the preceding claims, in which an additional dimension is taken into account in the transformation.

6. The method as claimed in claim 5, in which the additional transformation is carried out along a time dimension.

7. The method as claimed in one of the preceding claims, in which a side information item containing the order of the transformations is generated by the decision unit.

8. The method as claimed in one of the preceding claims, in which the horizontal transformation follows from the vertical transformation in that mirroring on a 45-degree axis is carried out before the transformation.

9. The method as claimed in one of the preceding claims, in which the vertical transformation follows from the horizontal transformation in that mirroring on a 45-degree axis is carried out before the transformation.

10. The method as claimed in one of the preceding claims, for use in a coder for compression of picture data.

11. The method as claimed in one of claims 7 to 10, in which the side information item is used in a decoder for decompression of the picture area.

12. The method as claimed in claim 10 or 11, in which modes of operation of the coder and/or of the decoder are determined according to an MPEG standard or according to an H.26x standard.

13. The method as claimed in one of the preceding claims, in which the transformation is a DCT transformation or an IDCT transformation which is the inverse thereof.

14. An arrangement for transforming a picture area,

having a decision unit which is set up in such a way that, depending on a value determined by the decision unit, firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation can be carried out.

GR 99 P 1137

Abstract

Method and arrangement for transforming a picture area

A method for transforming a picture area is specified, in which firstly a vertical transformation of the picture area and then a horizontal transformation of the picture area or, conversely, firstly the horizontal transformation and then the vertical transformation are carried out by a decision unit.

FIG 1

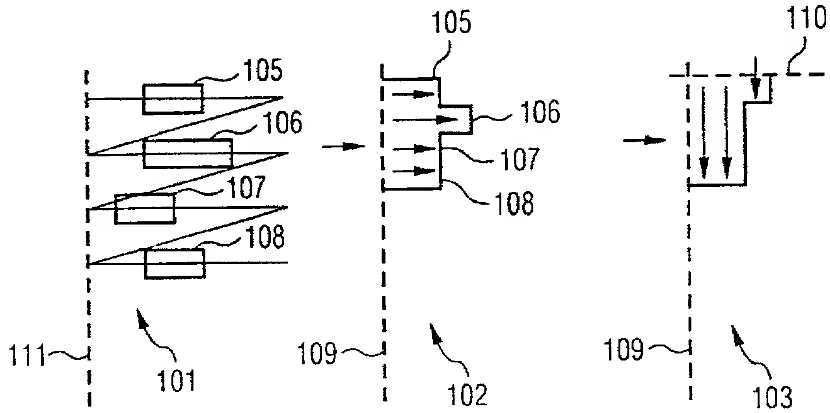
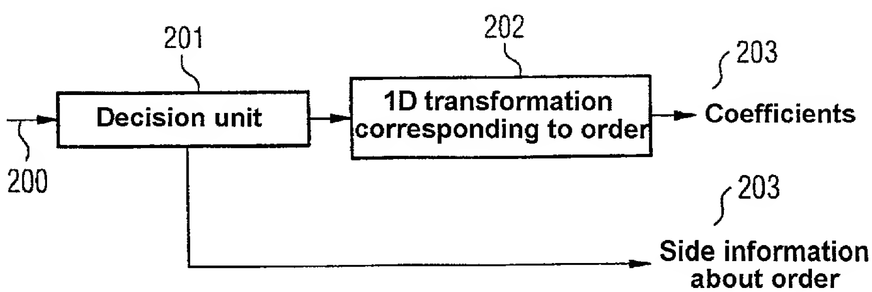

105
106
107
108
111
101
105
106
107
108
109
102
110
109
103

FIG 2


201
202
203
200
Decision unit
1D transformation corresponding to order
Coefficients
203
Side information about order

09/889934

FIG 3

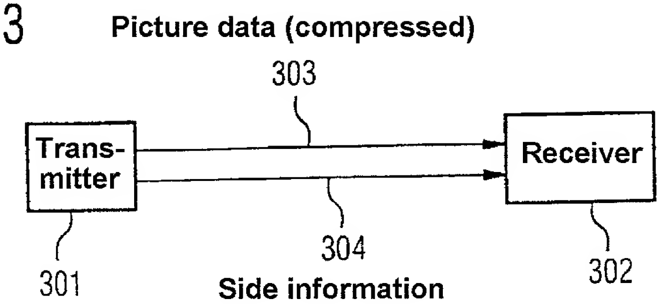
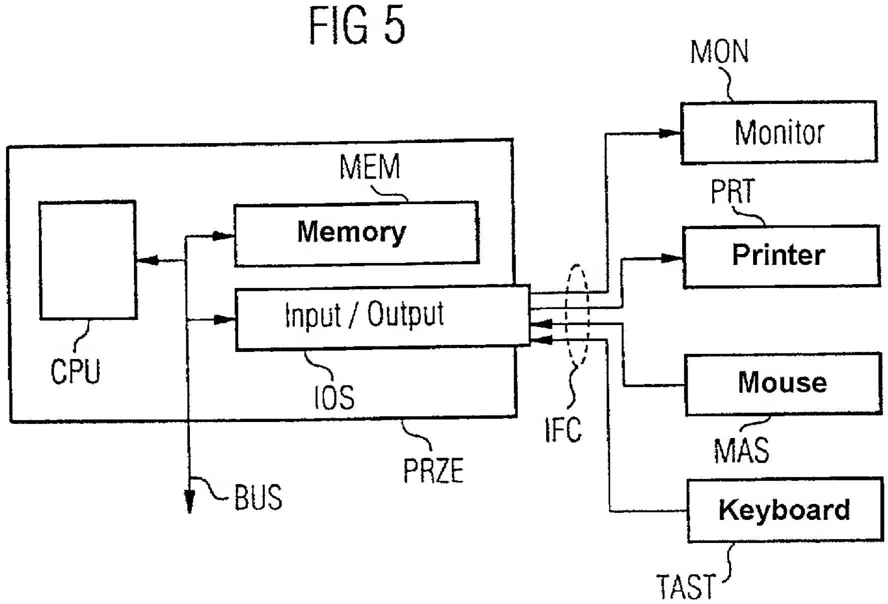


FIG 5



09/889934

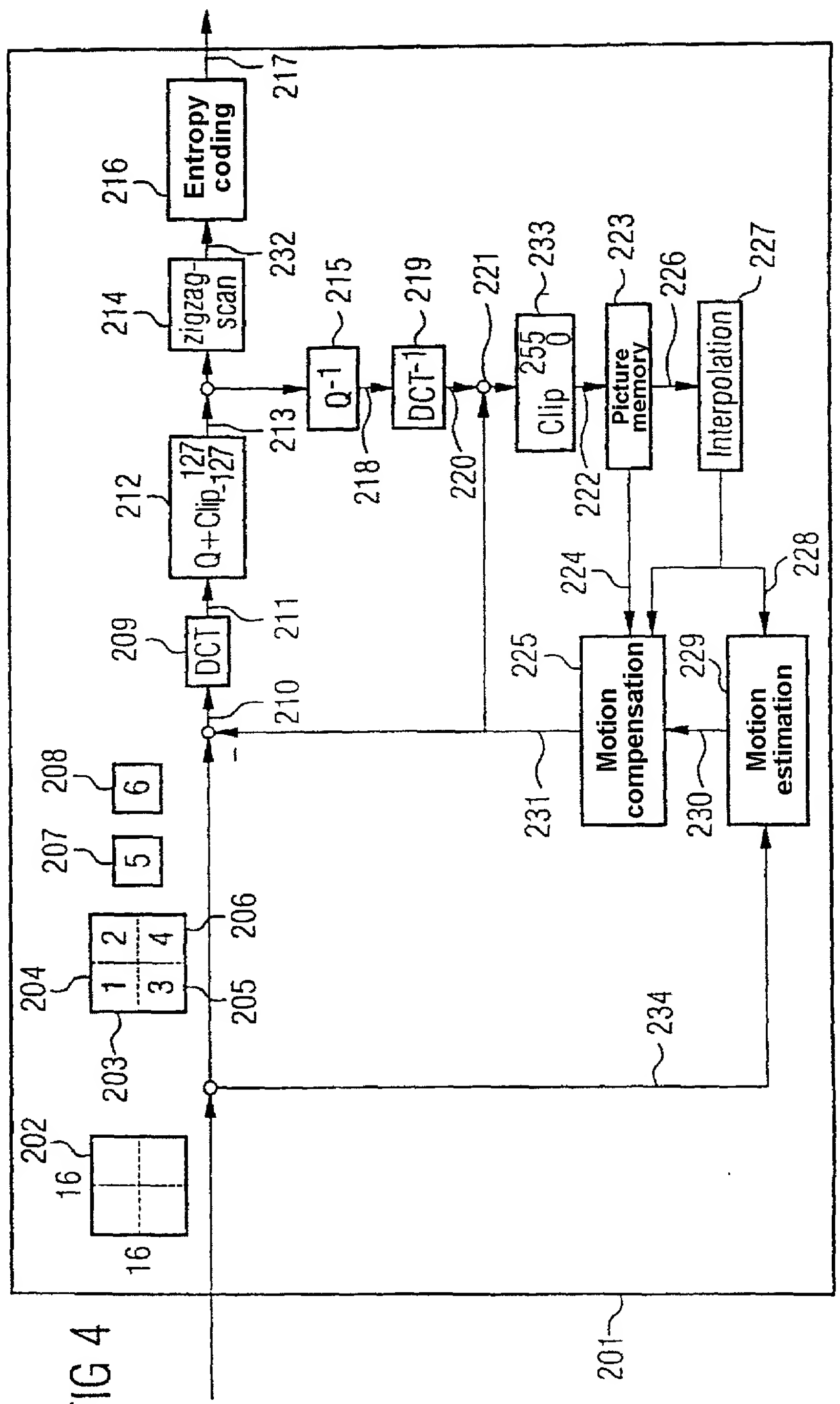


FIG 4

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren und Anordnung zur Transformation eines Bildbereichs

Method and arrangement for transforming an image area

deren Beschreibung

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 01.02.2000 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/00278
eingereicht wurde und am ______
abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

(check one)
☐ is attached hereto.
☒ was filed on 01.02.2000 as
PCT international application
PCT Application No. PCT/DE00/00278
and was amended on ______
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

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Patent and Trademark Office-U.S. DEPARTMENT OF COMMERCE
IDNR: 2590 / V: 99-1.00 / B:Val

German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

19903859.7 (Number) (Nummer)	DE (Country) (Land)	01.02.1999 (Day Month Year Filed) (Tag Monat Jahr eingereicht)	☒ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/00278 (Application Serial No.) (Anmeldeseriennummer)	01.02.2000 (Filing Date D, M, Y) (Anmeldedatum T, M, J)	anhängig (Status) (patentiert, anhängig, aufgegeben)	pending (Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

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German Language Declaration

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Staatsangehörigkeit: DE	Citizenship: DE
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85635 HOEHENKIRCHEN	85635 HOEHENKIRCHEN
Voller Name des zweiten Miterfinders (falls zutreffend):	Full name of second joint inventor, if any:
Unterschrift des Erfinders / Datum	Second Inventor's signature / Date
Wohnsitz: ,	Residence: ,
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).	*(Supply similar information and signature for third and subsequent joint inventors).*

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